Please type a plus sign (+) inside this box ⇒ [+]

PTO/SB/05 (12/97)
Approved for use through 09/30/00 OM 0651-0032
Patent and Trademark Office U S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

JC529 U.S. PRO 09/29/98

UTILITY PATENT APPLICATION TRANSMITTAL (Only for new nonprovisional applications under 37 CFR 1 53(b))	Attorney Docket No.	M-3417-1C US	Total Pages (This form)	2
	First Named Inventor or Application Identifier			
	Moshe Finarov			
	Express Mail Label No.	TB 894 714 832 US		

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: Assistant Commissioner for Patents
Box Patent Application
Washington, D.C. 20231

1. ☒ Fee Transmittal Form - ***see page 2 of this form.***
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification [Total Pages 13]
(preferred arrangement set forth below)
- Descriptive title of the Invention (on page 1)
- Background of the Invention (2 pages)
- Brief Summary of the Invention (1 page)
- Brief Description of the Drawings (1 page)
- Detailed Description (5 pages)
- Claim(s) (3 pages)
- Abstract of the Disclosure (1 page)

3. ☒ Drawing(s) (35 USC 113) [Total Sheets 9 as follows:
Informal filed with prior application (7 sheets), red-inked (2 sheets),
4. Oath or Declaration [Total Pages 5 as follows
Unsigned (2 pages) and Signed filed with Missing Parts (3 pages)
a. ☐ Newly executed (original or copy)
b. ☒ Copy from a prior application (37 CFR 1.63(d))
(for continuation/divisional with Box 17 completed)
c. ☒ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1 63(d)(2) and 1 33(b)
5. ☒ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
a. ☐ Computer Readable Copy
b. ☐ Paper Copy (identical to computer copy)
c. ☐ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & documents)
9. ☐ 37 CFR 3.73(b) Statement ☐ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☒ Information Disclosure Statement (IDS) (2 pages)/PTO-1449 (1 sheet) Citations ☒ 10 Copies of IDS
12. ☒ Preliminary Amendment (5 pages)
13. ☒ Return Receipt Postcard (MPEP 503)
(should be specifically itemized)
14. ☒ Small Entity Statement (2 pages)
☒ Statement filed in prior application; status still proper and desired
☐ Is no longer claimed.
15. ☒ Certified Copy of Priority Document(s)
(if foreign priority is claimed)
16. ☐ Other:

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:
☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No. 08/497,382, filed 06/29/95

18. CORRESPONDENCE ADDRESS

Customer Number or Bar Code Label or Correspondence address below

Name	**David W. Heid**		Reg. No. 25,875		
Attorneys for Applicant	**SKJERVEN, MORRILL, MacPHERSON, FRANKLIN & FRIEL LLP**				
Address	25 Metro Drive, Suite 700				
City	San Jose	State	CA	Zip Code	95110
Country:	United States	Telephone	(408) 453-9200	Fax	(408) 453-7979

Please type a plus sign (+) inside this box ⇒ [+]

19. Fee calculations.

CLAIMS (Number Filed)	(1) FOR	(2)		(3) NUMBER EXTRA		(4) RATE		(5) CALCULATIONS
3	TOTAL CLAIMS (37 CFR 1 16(c))	-20	=	0	x	$22	=	$ 0.00
1	INDEPENDENT CLAIMS (37 CFR 1 16(b))	-3	=	0	x	$82	=	$ 0.00
	MULTIPLE DEPENDENT CLAIMS (if applicable) (37 CFR 1.18(d))				+	$270.00	=	$ 0.00
						BASIC FEE (37 CFR 1 16(a))	=	$790.00
						Total of above Calculations	=	$ 790.00
	Reduction by 50% for filing by small entity (Note 31 CFR 1.9, 1.27, 1.28).						=	$ 395.00
						TOTAL	=	$ 395.00

20. FEES: The Commissioner is hereby authorized to credit overpayments or charge the following fees to Deposit Account No. **19-2386**:

a. ☒ Fees required under 37 CFR 1.16. (U.S. Application Filing Fees)
b. ☒ Fees required under 37 CFR 1.17. (Conditional Extension of Time Fees)
c. ☐ Fees required under 37 CFR 1.18. (Patent Issue Fees)

21. ☐ Other: _____

NOTE: **The prior application's correspondence address will carry over to this UPA UNLESS a new correspondence address is provided below.**

22. NEW CORRESPONDENCE ADDRESS					
Customer Number or Bar Code Label				New correspondence address below	
NAME					
ADDRESS					
CITY		STATE		ZIP CODE	
COUNTRY		TELEPHONE		FAX	

23. SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED		
Skjerven, Morrill, MacPherson, Franklin & Friel LLP 25 Metro Drive, Suite 700 San Jose, CA 95110 Tel. (408) 453-9200 Fax. (408) 453-7979		
Date:	March 25, 1998	
Name	**David W. Heid**	Reg. No. 25,875
Signature	David W. Heid	
Express Mail Label No.	TB 894 714 832 US	

409338 v1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Moshe Finarov		
Assignee:	Nova Measuring Instruments, Ltd.		
Title:	APPARATUS FOR OPTICAL INSPECTION OF WAFERS DURING POLISHING		
Serial No.:	Unknown	Filed:	March 25, 1998
Examiner:	Unknown	Group Art Unit:	Unknown
Docket No.:	M-3417-1C US		

San Jose, California
March 25, 1998

ASSISTANT COMMISSIONER FOR PATENTS
BOX PATENT APPLICATION
Washington, D. C. 20231

PRELIMINARY AMENDMENT AND STATEMENT UNDER 37 C.F.R. § 1.163(d)(2)

Dear Sir:

Prior to examining this continuing application (which is a continuation of U.S.S.N. 08/497,382, filed June 29, 1995), kindly amend the continuing application as follows:

IN THE TITLE

On page 1, after the title "APPARATUS FOR OPTICAL INSPECTION OF WAFERS DURING POLISHING", delete the names of the inventors "Eran Dvir, Eli Haimovich and Benjamin Shulman" as Moshe Finarov is the sole inventor in this application.

IN THE DRAWINGS

Please amend Figures 6-9 as shown in the red-ink mark up of these figures as originally filed in the prior application identified above.

LAW OFFICES OF
SKJERVEN, MORRILL,
MacPHERSON, FRANKLIN
& FRIEL LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

IN THE SPECIFICATION

Page 1, before the first line, insert, --This Application is a continuation of application serial no. 08/497,382, filed June 29, 1995.--

Page 3, line 16, kindly delete "or water".

IN THE CLAIMS

Kindly cancel claims 1-16.

Kindly add the following new claims:

17. A polisher having the ability to measure the thickness of a top layer of a wafer, the polisher comprising:

a polishing unit which polishes said top layer in the presence of a liquid;

an optical measurement station, mounted within said polisher but apart form said polishing unit; and

means to move said wafer from said polishing unit to said optical measurement station while said wafer is still wet;

wherein said optical measurement station comprises;

a liquid holding unit having a window in a bottom surface thereof and holding liquid therein which receives said wafer; and

an optical thickness measuring unit located on a non-liquid side of said window which measures the thickness of said top layer while said wafer is immersed in said liquid.

LAW OFFICES OF
SKJERVEN, MORRILL,
MacPHERSON, FRANKLIN
& FRIEL LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

18. A polisher according to Claim 17 and having a layer of liquid between said window and said wafer during operation of said optical thickness measuring unit.

19. A polisher according to Claim 17 wherein said optical thickness measuring unit includes:

an illumination optical unit for directing light towards said wafer;

an imaging unit for imaging said top layer;

a spectrophotometric detector; and

separation optics for providing light reflected from said wafer separately to said imaging unit and to said spectrophotometric detector, the separation optics comprising an objective lens, a pinhole mirror and first and second relay lenses wherein said first relay lens focuses the light passing through said pinhole mirror onto said spectrophotometric detector and wherein said second relay lens focuses the light reflected from said pinhole mirror onto said imaging unit.

DELETION OF INVENTORS

In view of the invention being pursued in this continuing application, the following persons which are named on the Declaration For Patent Application in the parent application should be deleted because they are not inventors in this continuation application: Eran Dvir; Eli Haimovich; and Benjamin Shulman.

REMARKS

This is a continuation application of Serial No. 08/497,382, filed June 29, 1995.

LAW OFFICES OF
SKJERVEN, MORRILL,
MacPHERSON, FRANKLIN
& FRIEL LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

The sole inventor of this continuation application is Moshe Finarov. The other three inventors, Eran Dvir, Eli Haimovich, and Benjamin Shulman, have been deleted from this continuation application.

The original Claims 1-16 of Serial No. 08/497,382 have been canceled and new Claims 17-19, directed to the combination of a polishing unit and an optical thickness measuring unit, have been added.

AMENDMENTS TO DRAWINGS AND THE SPECIFICATION

The specification has been amended on page 1, before the first line, to state that this is a continuation application of serial no. 08/497,382, filed June 29, 1995.

Applicants have discovered a typographical error on page 3 and have corrected it in this amendment. The amendments requested to the drawings are for the purpose of conforming the drawings to the specification, and to correct in regard to Figure 8 an obvious reference character number error.

DISCUSSION OF PREVIOUSLY CITED PRIOR ART

As previously discussed, Burke et al. describe a wafer polishing tool which has a separate measuring station and means for moving the wafer to the measuring station. The measuring station performs electrical testing of the wafer through an electrolyte. Lustig et al. show in-situ reflectance measurements of a wafer being polished.

The present invention, on the other hand and as recited in new Claim 17-19, is a polisher which optically measures the thickness of a top layer of a wafer.

Neither Burke et al. nor Lustig et al. show an optical thickness measuring unit. The optical unit of Lustig et al. measures reflectance which is an indication of the shininess, but

LAW OFFICES OF
SKJERVEN, MORRILL,
MacPHERSON, FRANKLIN
& FRIEL LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

not the thickness, of the top layer of the wafer. The thickness measuring unit of Burke et al. is an electrical measurement. The replacement of the Lustig et al. measuring unit does not provide the unit of Burke et al. with an optical thickness measuring unit.

Unlike prior art optical thickness measuring units, the present invention locates the measurement station within the polisher, but apart from the polishing unit. Because the optical measurement station is separate from the polishing unit, the optical unit does not disturb the polishing operation nor are its optical properties constrained by the presence or operation of the polishing unit. Furthermore, there is no need to dry the wafer after the polishing operation since, in the present invention, the optical measurement occurs while the wafer is wet.

Claim 17 is, therefore, deemed to be allowable. Claims 18-19, which depend from Claim 17 and add additional subject matter thereto are deemed to be allowable for at least the reason of their dependency on Claim 17.

In view of the above mentioned amendments and remarks, it is respectfully submitted that the pending claims are patentable over the art of record and are in condition for allowance. Prompt notice of allowance is respectfully solicited.

Respectfully submitted,

EXPRESS MAIL LABEL NO:
TB 894 714 832 US

David W. Heid
Attorney for Applicant(s)
Reg. No. 25,875

LAW OFFICES OF
SKJERVEN, MORRILL,
MacPHERSON, FRANKLIN
& FRIEL LLP

25 METRO DRIVE
SUITE 700
SAN JOSE, CA 95110
(408) 453-9200
FAX (408) 453-7979

Express Mail Label No.:
TB 894 714 832 US

APPARATUS FOR OPTICAL INSPECTION OF WAFERS DURING POLISHING

Eran Dvir, Moshe Finarov, Eli Haimovich and Beniamin Shulman

FIELD OF THE INVENTION

The present invention relates to wafer polishing apparatus in general and to measuring systems incorporated into such apparatus in particular.

BACKGROUND OF THE INVENTION

Wafer polishing systems are known in the art. They polish the top layer of semiconductor wafers to a desired thickness. To do so, the wafer being polished is immersed in a slurry of water and chemicals during the polishing process. Once the wafer has been polished and washed down, it is placed into an exit station known by some companies as a "water track", after which the wafer is placed into a cassette of wafers. The cassette is maintained within a water bath until full, after which the entire cassette is brought to a cleaning station to remove any chemicals and slurry particles still remaining on the wafers in the cassette and to dry the wafers. After cleaning, the wafers are brought to a measurement station to determine if the polisher produced the desired thickness of their top layers.

Fig. 1, to which reference is now briefly made, illustrates a prior art water track, such as the water track of the #372 Polisher manufactured by IPEC Westech Inc. of Phoenix, Arizona, USA. The water track, labeled 10, comprises a frame 12 and a base 14. Frame 12 has jet holes 16 connected to jets (not shown) which emit streams 18 of water through holes 16. Base 14 has holes 20 connected to bubblers (not shown) which bubble small amounts of water 22 through holes 20. When a wafer 25 is dropped into water track 10, pattern-side down, the jets and bubblers are activated. Streams 18, from the water jets, serve to force the wafer 25 in the direction indicated by arrow 24. Small streams 22 push the wafer 25 slightly away from the base 14 and ensure that, while the wafer 25 moves through the track, it never rubs against base 14 and thus, the pattern on the wafer is not scratched.

Other companies produce polishers whose exit stations are formed just of the cassettes. Such a polisher is produced found in the 6DS-SP polisher of R. Howard Strasbaugh Inc. San Luis Obispo, California, USA.

SUMMARY OF THE PRESENT INVENTION

It is an object of the present invention to provide a measurement system installable within a polishing machine and, more specifically, within the exit station of a polishing machine.

In accordance with a preferred embodiment of the present invention, the present invention includes an optical system, which views the wafer through a window in the exit station, and a gripping system, which places the wafer in a predetermined viewing location within the exit station while maintaining the patterned surface completely under water. The present invention also includes a pull-down unit for pulling the measurement system slightly below the horizontal prior to the measurement and returns the measuring system to horizontal afterwards.

In accordance with a first preferred embodiment of the present invention, the gripping system includes a raisable gate which collects the wafer in a predetermined location, and a gripper which grips the wafer, carries it to the viewing location and immerses the wafer, along a small angle to the horizontal, in the water or water. The gripper also holds the wafer in place during the measurement operation, after which, it releases the wafer and the raisable gate is raised.

The present invention incorporates the method of immersing an object into water such that very few bubbles are produced on the wafer surface. The method of the present invention preferably includes the step of immersing the object while it is held such that its surface plane is at a small angle to the horizontal.

In a second embodiment, the measurement system includes a water bath and a gripping system thereabove. The gripping system includes wafer holding elements, which receive the wafer, and a gripper whose initial location is above the expected reception location of the wafer. The gripper is flexibly connected at an angle to a piston such that the wafer is immersed in the water at an angle to the horizontal.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Fig. 1 is a schematic illustration of a prior art water track:

Fig. 2 is a schematic illustration of a measurement system installable within a polishing machine, the measurement system being constructed and operative in accordance with a preferred embodiment of the present invention;

Figs. 3, 4, 5, 6, 7 and 8 are schematic, side view illustrations of a gripping system forming part of the measurement system of Fig. 2 in various stages of operation;

Fig. 9 is a schematic illustration of an example optical system forming part of the measurement system of the present invention;

Fig. 10 is a top view of a second embodiment of the measurement system of the present invention; and

Figs. 11, 12 and 13 are side views of the measurement system during receipt, transfer and measurement of the wafer, respectively.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Reference is now made to Fig. 2, which illustrates a measurement unit installable within a polishing machine, such as the IPEC Westech machine, the measurement system being constructed and operative in accordance with a preferred embodiment of the present invention and to Figs. 3, 4, 5, 6, 7 and 8 which illustrate the operation of a gripping system forming part of the measurement system of Fig. 2. Similar reference numerals are utilized to refer to elements of the water track previously discussed.

The measurement system, labeled 30, comprises an optical system 32 and a gripping system 34 operative in conjunction with a water track 36. The optical system 32 can be any optical system which measures the thickness of the top layer of the wafer through water. Fig. 9 provides one example of such a optical system; other optical systems are also incorporated into the present invention.

The gripping system 34 comprises a raisable gate 40, a translatable gripper 42, a vacuum pad 44 and a vacuum system 46. Gate 40 is controlled by a lifting mechanism 48 which raises and lowers gate 40 as necessary. Gate 40 has an upper surface 50 with a curved outer edge 52 and a plurality of protrusions 54 extending downward into the water from the upper surface 50. Protrusions 54 provide a lower surface onto which the gate 40 is lowered while enabling the water to pass through the gate 40. Curved edge 52 is shaped to match the curved edge of the wafer 25 so that, when gate 40 is in its lowered position, gate 40 will both keep the wafer 25 from passing out of the water track and to hold the wafer 25 in a repeatable location.

Gripper 42 translates between the wafer collecting position defined by the curved edge 52 and a wafer measuring location indicated in Fig. 2 by the wafer 25. Although not visible in Fig. 2, the base of the water track at the wafer measuring location has been replaced by a window 60 (Figs. 3 - 9) to enable the optical system 32 to view the patterned surface 62 of the wafer 25. For the purposes of the explanation, the patterned surface 62 is shown exaggeratedly in the Figures.

Gripper 42 can be translated by any translation system; an example of one such system is provided in Fig. 2 and labeled 64.

The vacuum pad 44 is typically a bellows-shaped pad and is mounted at the end of the gripper 42 and is connected to the vacuum system 46. The vacuum pad 44 creates a suction so that gripper 42 can raise the wafer 25 and move it from the wafer collecting position to the wafer measuring location. In addition, the vacuum is maintained during the measurement and only released once the measurement is complete.

Figs. 3 - 8 illustrate the operation of the gripping system 34. Initially, and as shown in Fig. 3, the jets, labeled 70, and the bubblers, labeled 72, of the water track are operated and the gate 40 is lowered. The polisher (not shown) places the wafer 25 within the water track and the streams 16 from the jets 70 push the wafer 25 towards the gate 40. The gripper 42 is at the wafer collecting position, shown to the left in Figs. 3 - 8.

Once the wafer 25 is in the wafer collecting position, as shown in Fig. 4, gripper 42 lowers vacuum pad 44 to grab the wafer 25. It will be appreciated that gripper 42 can be formed of any suitable mechanism, such as a piston, which can move vacuum pad 44 up and down on command. Since bubblers 72 are operating, the small streams 22 maintain the wafer 25 away from the base 14 of the water track.

The gripper 42 then pulls the wafer 25 out of the water (Fig. 5) and the jets 70 are deactivated. In accordance with a preferred embodiment of the present invention, the axis 74 of symmetry of the vacuum pad 44 is formed at a small angle α from the vertical axis 76. As a result, a long axis 75 of the wafer 25 is at the same small angle α to the horizontal axis 78. Angle α is typically in the range of 2 - 5°.

Translation unit 64 then moves gripper 42 to the wafer measuring position, shown to the right in Figs. 4 - 8. At the same time and as shown in Fig. 6, a pull-down mechanism slightly lowers the entire water track, gripping and optical system unit (at an angle of 1 - 3°), about a hinge 80 (Figs. 2 - 8), to force the water toward the wafer measuring position. Other methods of forcing the water towards the measuring position are also incorporated in the present invention.

After the lowering of the water track, gripper 42 lowers the wafer 25 towards the window 60. Since the vacuum pad 44 is angled, the wafer 25 does not enter the water all at once. Instead, wafer 25 enters the water gradually. Initially, only the side labeled 82 is immersed. As the gripper 42 pushes the vacuum pad 44 further down, more and more of the

wafer 25 becomes immersed until the entire wafer 25 is within the water. Vacuum pad 44 is flexible enough to accommodate the changed angle of wafer 25.

It will be appreciated that, by gradually immersing the wafer in the water, few, if any, bubbles are created near the patterned surface of the wafer 25.

It is noted that the wafer 25 does not rest against the window 60. Instead, it is held against protruding surfaces 84 such that there is a layer of water 86 between the wafer 25 and window 60. Due to the gradual immersion of wafer 25, layer 86 of water has little, if any, bubbles in it and therefore provides a uniform connecting medium between the optical system 32 and the patterned surface 62 of wafer 25.

Once the optical system 32 has finished measuring the patterned surface 62 of wafer 25, gripper 42 returns vacuum pad 44, with wafer 25 still attached, to its upper position. The pull-down mechanism rotates the water track about hinge 80 to return to its original position, gate 40 is raised, and jets 70 and bubblers 72 are activated. The vacuum system 46 releases the vacuum and the wafers 25 falls into the water track. The flow of water causes the wafer 25 to move toward and under the now raised gate 40. A sensor 90 determines when the wafer 25 successfully passes out of the water track. The process described hereinabove can now begin for the next wafer.

Reference is now made to Fig. 9 which schematically illustrates an example of a suitable optical system 32. Optical system 32 is a microscope-based spectrophotometer and comprises an objective lens 100, a focusing lens 102, a beam splitter 104, a pin hole mirror 106, a relay lens 108 and a spectrophotometer 110. It additionally comprises a light source 112, a condenser 114, a charge coupled device (CCD) camera 116 and a second relay lens 118.

Light from light source 112 is provided, along an optical fiber 113, to condenser 114. In turn, condenser 114 directs the light towards beam splitter 104. Beam splitter 104 directs the light towards the wafer surface via lenses 102 and 100 and via window 60 and water layer 86.

The reflected light from the patterned surface 62 is collected by objective 100 and focused, by lens 102, onto pin hole mirror 106. Relay lens 108 receives the light passed through pin hole mirror 106 and focusses it onto the spectrophotometer 110.

Pin hole mirror 106 passes light through its hole towards spectrophotometer 110 and directs the light hitting the mirror surface towards CCD camera 114. Second relay lens 118 receives the light reflected by pin hole mirror 106 and focusses it onto the CCD camera 114

Since the pinhole is placed at the center of the image plane which is the focal plane of lens 102, it acts as an aperture stop, allowing only the collimated portion of the light beam to pass through. Thus, the pinhole drastically reduces any scattered light in the system. Relay lens 108 collects the light from the pinhole and provides it to spectrophotometer 110.

Furthermore, since the pinhole is located at the image plane of the optical imaging system (lenses 100 and 102), only that portion of the light, reflected from the surface of wafer 25, which is the size of the pinhole divided by the magnification will come through the pinhole. Relay lens 118 collects the light and focusses it onto the CCD camera 114.

The pinhole serves to locate the measurement spot in the image of the wafer 25. Since the pinhole allows light to pass through it, rather than being reflected toward the CCD camera 114, the pinhole appears as a sharp dark point in the image produced by the lens 118. Thus, when viewing the CCD image, the location of the measurement spot is immediately known, it being the location of the dark spot.

Reference is now made to Figs. 10 - 14 which illustrate the thickness measuring of the present invention implemented in a polishing machine similar to that produced by Strasbaugh which has no water track. In this embodiment, the polishing machine or an external robot (not shown) brings the wafers 25 to an exit station of the polisher. When the measurement has finished, the robot brings the wafers 25 to their cassette at another exit station. Fig. 10 is a top view and Figs. 11, 12 and 13 illustrate the measuring station in three states.

The measuring station 130 comprises a gripping unit 132, an optical system 134 and a water bath 136. The optical system 134 is located beneath the water bath 136 and can be any suitable optical system, such as the one described hereinabove. As in the previous embodiment, the water bath 136 has a window in its bottom surface, labeled 140 in Fig. 11, through which the optical system 134 can illuminate the wafer 25.

The gripping unit 132 comprises a wafer support 150, illustrated as being formed of two support elements, a vacuum pad 152, similar to vacuum pad 44, and a piston 160. The polisher places the wafer 25 on the wafer support 150 while the vacuum pad 152 is initially in a position above the support 150, as shown in Fig. 11. Once the wafer support 150 has

the wafer in a predefined position, the vacuum pad 152, which is controlled by piston 160, moves toward the wafer and grabs it by applying a vacuum Now that the vacuum pad 152 is holding the wafer, the wafer supports 150 move away, as indicated

The piston 160 then pushes the vacuum pad-wafer combination toward the water bath 136. This is shown in Fig. 12 which also illustrates that the vacuum pad 152 holds the wafer 25 at a small angle α to the horizontal. The angle α is provided since, as in the previous embodiment, the axis of symmetry of the vacuum pad 152 is formed at a small angle α from the vertical axis. As in the previous embodiment, by immersing the wafer 25 into the water at the angle α, few, if any, bubbles, remain on the undersurface of the wafer after full immersion.

Fig. 13 illustrates the wafer 25 at its fully immersed, measurement position. Typically, wafer 25 does not directly touch the water surface 163 of the window 140; instead, it sits on a measurement support 168. The result is that there is a water layer 164 between the wafer 25 and the surface 163 of the window.

Once the measurement process has finished, the piston 160 returns the wafer 25 to its original position and the wafer support elements 150 return to their wafer receiving position. The piston 160 places the wafer 25 on the wafer support elements 150 and releases the vacuum. The external robot can now take the wafer to another exit station where there is a cassette of processed and measured wafers.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined by the claims which follow:

CLAIMS

1. A wafer polisher having thickness measurement capabilities, the polisher comprising:
   a. a polishing unit for polishing a top layer of a wafer in the presence of a slurry;
   b. a thickness measuring unit mounted on said polisher for measuring the thickness of said top layer while said wafer is immersed in said water.

2. A polisher according to claim 1 and wherein said polisher comprises an output track with said water flowing therein, said output track comprises a bottom surface having a window mounted therein.

3. A polisher according to claim 2 and wherein said thickness measuring unit comprises:
   a. a curved gate having a radius of curvature generally similar to that of said wafer, said curved gate being located at a gripping position;
   b. a gripper for moving said wafer from said gripping position to a measuring position above a layer of water located above said window; and
   c. an optical system, mounted underneath said window, for measuring said thickness of said top layer through said window and said layer of water.

4. A polisher according to claim 1 and also comprising a pull-down unit for pulling at least said bottom surface below the horizontal.

5. A thickness measuring unit for mounting on a water track of a polisher for measuring the thickness of a top layer of a wafer, said thickness measuring unit comprising:
   a. a curved gate having a radius of curvature generally similar to that of said wafer, said curved gate being located at a gripping position;
   b. a window mounted in a bottom surface of said water track;
   c. a gripper for moving said wafer from said gripping position to a measuring position above a layer of water located above said window; and
   d. an optical system, mounted underneath said window, for measuring said thickness of said top layer through said window and said layer of water.

6. A unit according to claim 5 and wherein said gripper comprises a gripping pad mounted to said gripper, wherein an axis of symmetry of said gripping pad is at an angle to the horizontal.

7. A unit according to claim 6 and wherein said gripping pad comprises a bellows shaped pad and operates in conjunction with a vacuum pump for creating a suction within said pad.

8. A polisher according to claim 1 and wherein said thickness measuring unit comprises:

a. a water bath having a window in a bottom surface thereof;

b. a gripper for moving said wafer from a gripping position above said water bath to a measuring position above a layer of water located above said window; and

c. an optical system, mounted underneath said window, for measuring said thickness of said top layer through said window and said layer of water.

9. A thickness measuring unit for mounting on a water bath for measuring the thickness of a top layer of a wafer, said thickness measuring unit comprising:

a. a water bath;

b. a window mounted in a bottom surface of said water bath;

c. a gripper for moving said wafer from a gripping position above said water bath to a measuring position above a layer of water located above said window; and

d. an optical system, mounted underneath said window, for measuring said thickness of said top layer through said window and said layer of water.

10. A unit according to claim 9 wherein said gripper comprises a gripping pad mounted to said gripper, and wherein an axis of symmetry of said gripping pad is at an angle to the horizontal.

11. A method of placing a wafer in a water without introducing generally any bubbles underneath said wafer, the method comprising the step of immersing said wafer within said water such that the plane of said wafer is at an angle to the surface of said water.

12. A method according to claim 11 and comprising the step of pressing said wafer against a surface which is parallel to a measurement window underneath the surface of said water.

13. A method of measuring the thickness of a polished top layer of a wafer before removing said wafer from a polishing machine, said method comprising the steps of:

a. picking said wafer up from a gripping position;

b. moving said wafer from said gripping position to a measuring position;

c. placing said wafer in said measuring position underneath a surface of said water but a thin layer of said water located above a window; and

d. measuring said thickness of said top layer through said window and said layer of water.

14. A method according to claim 13 and wherein said step of placing comprises the step of immersing said wafer within said water such that the plane of said wafer is at an angle to the surface of said water.

15. A method according to claim 13 wherein said water is held within a water bath and wherein said step of moving comprises the step of changing the angle of the lower surface of said water bath to move said water towards said measuring position.

16. A method according to claim 14 wherein said water is held within a water bath and wherein said step of moving comprises the step of changing the angle of the lower surface of said water bath to move said water towards said measuring position.

ABSTRACT

An optical system is disclosed for the inspection of wafers during polishing which also includes a measurement system for measuring the thickness of the wafer's top layer. The optical system views the wafer through a window and includes a gripping system, which places the wafer in a predetermined viewing location while maintaining the patterned surface completely under water. The optical system also includes a pull-down unit for pulling the measurement system slightly below the horizontal prior to the measurement and returns the measuring system to the horizontal afterwards.

I hereby certify that this correspondence is being deposited with the United States Postal Service as express mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on June 29, 1995. Express Mail Receipt No. TB 856095075 US

6/29/95
Date of Signature

Atty. Docket No. M-3417 US

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of subject matter (process, machine, manufacture, or composition of matter, or an improvement thereof) which is claimed and for which a patent is sought by way of the application entitled "APPARATUS FOR OPTICAL INSPECTION OF WAFERS DURING POLISHING"

which (check)
- [x] is attached hereto.
- [ ] and is amended by the Preliminary Amendment attached hereto.
- [ ] was filed on _____ as Application Serial No. _____
- [ ] and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information known to me to be material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
113829 (Number)	Israel (Country)	23 May, 1995 (Day/Month/Year Filed)	**Yes**	No
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	Yes	No
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as any subject matter of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith:

Alan H. MacPherson (24,423); Thomas S. MacDonald (17,774); Richard Franklin (19,128); Kenneth E. Leeds (30,566); Paul J. Winters (25,246); Brian D. Ogonowsky (31,988); David W. Heid (25,875); Guy W. Shoup (26,805); Forrest E. Gunnison (32,899); Norman R. Klivans (33,003); David H. Carroll (29,903); Edward C. Kwok (33,938); Patrick T. Bever (33,834); David E. Steuber (25,557); Michael Shenker (34,250); Laura Terlizzi (31,307); T. Lester Wallace (34,748); Ronald J. Meetin (29,089); Andrew C. Graham (36,531); Ken John Koestner (33,004); Mark P. Kahler (29,178); Stephen A. Terrile (32,946); Omkar K. Suryadevara (36,320); David T. Millers (37,396); E. Eric Hoffman (38,186); and Lawrence E. Lycke (38,540).

Address all correspondence and telephone calls to:

Forrest E. Gunnison, Esq.
Attorney for Applicant(s)
SKJERVEN, MORRILL, MacPHERSON, FRANKLIN & FRIEL
25 Metro Drive, Suite 700
San Jose, California 95110-1349

Telephone: 408-453-9200
Facsimile: 408-453-7979

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor Eran Dvir
Inventor's signature _____ Date _____
Residence Givatayim, Israel Citizenship Israeli
Post Office Address 15 Hapalmach Street
Givatayim, 53406, Israel

Full name of second joint inventor, if any Moshe Finarov
Inventor's signature _____ Date _____
Residence Rehovot, Israel Citizenship Israeli
Post Office Address 4/25 Shkolnik Street,
Rehovot, 76209, Israel

Full name of third joint inventor, if any Eli Haimovich
Inventor's signature _____ Date _____
Residence Moshav Magshimim, Israel Citizenship Israel
Post Office Address 23 Haarava Street
Moshav Magshimim, 56910, Israel

Full name of fourth joint inventor, if any Beniamin Shulman
Inventor's signature _____ Date _____
Residence Rehovot, Israel Citizenship Israel
Post Office Address 524/20 Hagana Street
Rehovot, 76100, Israel

L:\DMS\2256\M-3417_US\0135132 01

Attorney Docket No M-3417 US

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of subject matter (process, machine, manufacture, or composition of matter, or an improvement thereof) that is claimed and for which a patent is solicited by way of the application entitled APPARATUS FOR OPTICAL INSPECTION OF WAFERS DURING POLISHING" which (check) [ ] is attached hereto.
[ ] and is amended by the Preliminary Amendment attached hereto.
[X] was filed on June 29, 1995 as Application Serial No. 08/497,382
[ ] and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified application, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
113829 (Number)	Israel (Country)	23 May, 1995 (Day/Month/Year Filed)	**Yes**	No
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	Yes	No
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as any subject matter of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

NA (Application Serial No.)	_____ (Filing Date)	_____ (Status-patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status-patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith:

Alan H. MacPherson (24,423); Thomas S. MacDonald (17,774); Richard Franklin (19,128); Kenneth E. Leeds (30,566); Paul J. Winters (25,246); Brian D. Ogonowsky (31,988); David W. Heid (25,875); Guy W. Shoup (26,805); Forrest E. Gunnison (32,899); Norman R. Klivans (33,003); David H. Carroll (29,903); Edward C. Kwok (33,938); Patrick T. Bever (33,834); David E. Steuber (25,557); Michael Shenker (34,250); Laura Terlizzi (31,307); T. Lester Wallace (34,748); Ronald J. Meetin (29,089); and David R. Graham (36,150); Ken John Koestner (33,004); Mark P. Kahler (29,178); Stephen A. Terrile (32,946); Omker K. Suryadevara (36,320); David T. Millers (37,396); E. Eric Hoffman (38,186); and Lawrence E. Lycke (38,540).

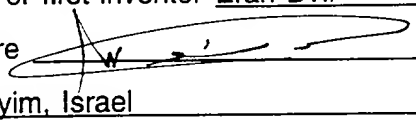
Address all correspondence and telephone calls to:

Forrest E. Gunnison, Esq.
Attorney for Applicant(s)
SKJERVEN, MORRILL, MacPHERSON, FRANKLIN & FRIEL
25 Metro Drive, Suite 700
San Jose, California 95110-1349

Telephone: 408-453-9200
Facsimile: 408-453-7979

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

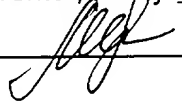
Full Name of sole or first inventor Eran Dvir

Inventor's signature  Date 1.10.95

Residence Givatayim, Israel Citizenship Israeli

Post Office Address 15 Hapalmach St., Givatayim 53406, Israel

Full Name of second joint inventor, if any Moshe Finarov

Inventor's signature  Date 1.10.95

Residence Rehovot, Israel Citizenship Israeli

Post Office Address 4/25 Shkolnik St., Rehovot 76209, Israel

Attorney Docket No M-3417 US

Full Name of third joint inventor, if any Eli Haimovich

Inventor's signature Eli Haimovich Date 1/10/95

Residence Moshav Magshimim, Israel Citizenship Israeli

Post Office Address 23 Haarava St., Moshav Magshimim 56910, Israel

Full Name of fourth joint inventor, if any Beniamin Shulman

Inventor's signature [signature] Date 1.10.95

Residence Rehovot, Israel Citizenship Israeli

Post Office Address 524/20 Hagana St., Rehovot 76100, Israel

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Eran Dvir et al.
Assignee: Nova Measuring Instruments, Ltd.
Title: **APPARATUS FOR OPTICAL INSPECTION OF WAFERS DURING POLISHING**
Serial No.: Filed: **June 29, 1995**
Examiner: Unknown Art Unit: Unknown
Attorney Docket No.: M-3417 US

COMMISSIONER OF PATENTS AND TRADEMARKS
WASHINGTON, D.C. 20231

SMALL BUSINESS CONCERN
DECLARATION BY ASSIGNEE

Dear Sir:

With respect to the above-identified invention and patent application included herewith for filing in the U.S. Patent and Trademark Office the undersigned officer of the assignee of such application hereby declares that:

Exclusive rights to the above-identified invention have been conveyed to and remain with assignee by virtue of an Assignment dated on or about the date of this verification. I am empowered to act on behalf of said assignee. I verily believe that assignee qualifies as a small business concern as defined in 13 C.F.R. Section 121.12 and reproduced in 37 C.F.R. Section 1.9(d), namely, the concern's number of employees, including those of its affiliates, does not exceed 500 persons and the concern has not assigned, granted, conveyed, or licensed, and is under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 C.F.R. Section 1.9(c) if that person has made the invention, or to any concern which would not qualify as a small business concern under 37 C.F.R. Section 1.9(d) or a nonprofit organization under 37 C.F.R. Section 1.9(e).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued

thereon.

Dated: July 20, 1995 Respectfully submitted,

Nova Measuring Instruments, Ltd.
Weizmann Scientific Park
P.O.Box 266
Rehovot 76100, Israel

Signature: [signature]

Full Name: GIORA DISHON

Title: Managing Director

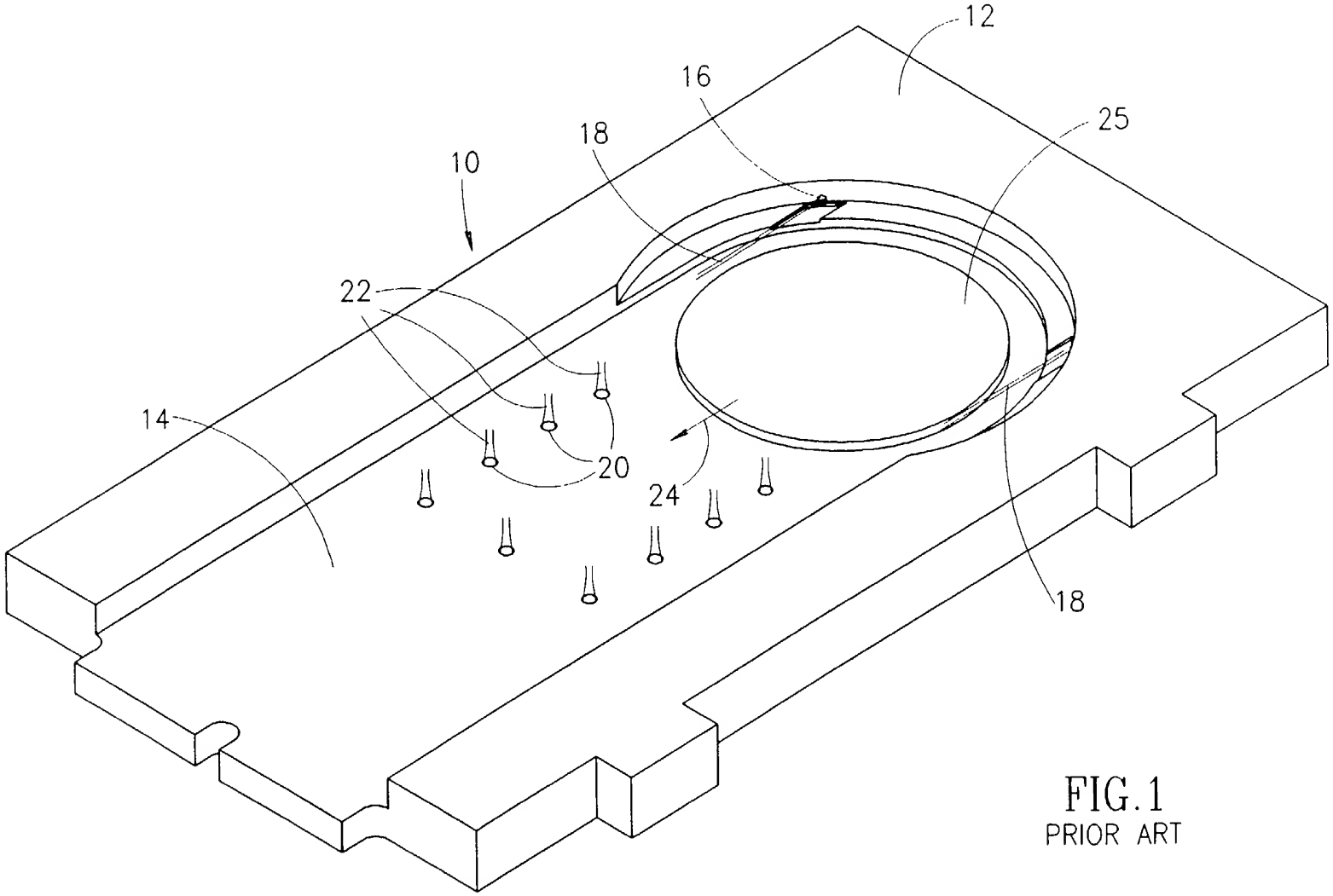


FIG.1
PRIOR ART

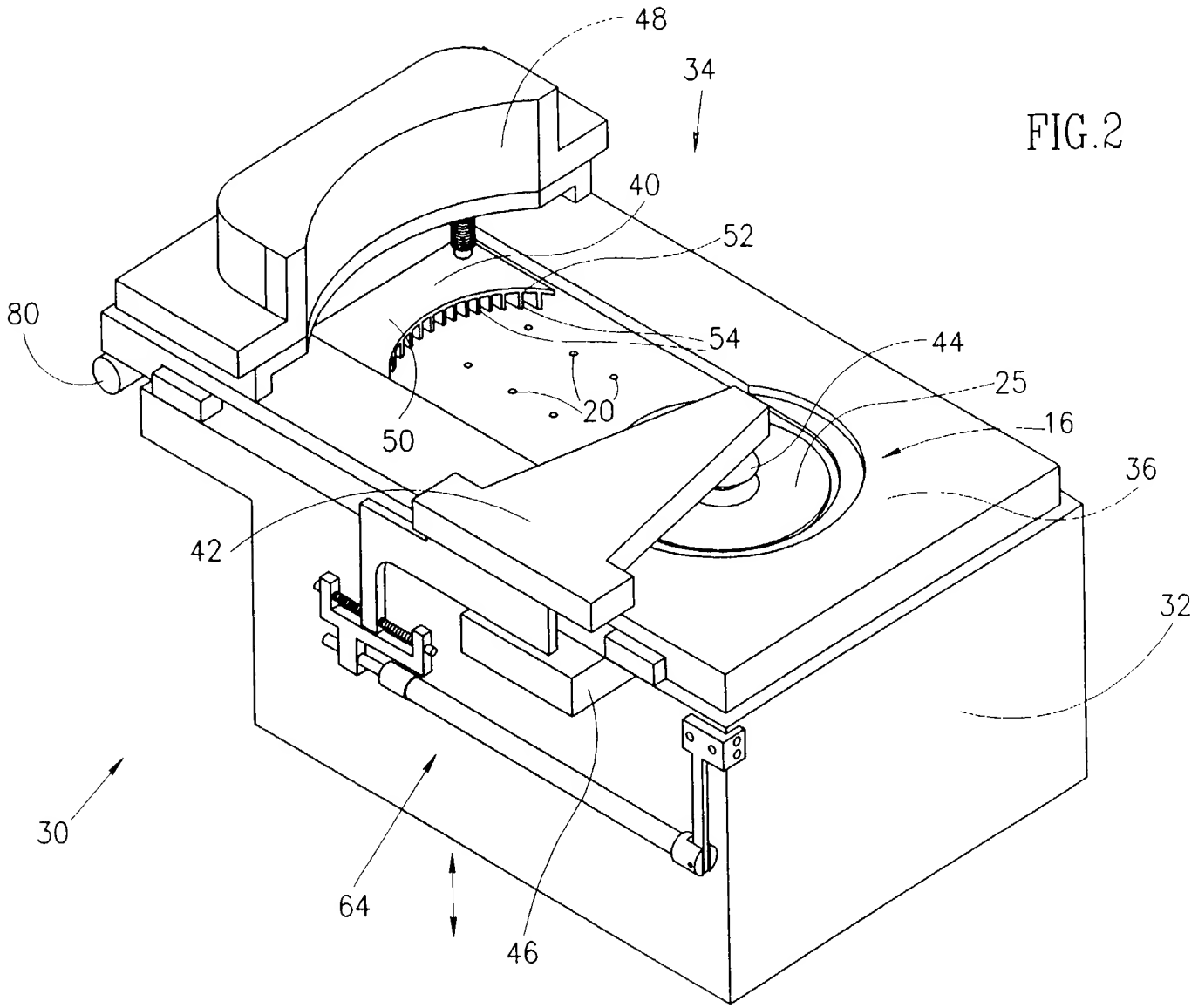


FIG.2

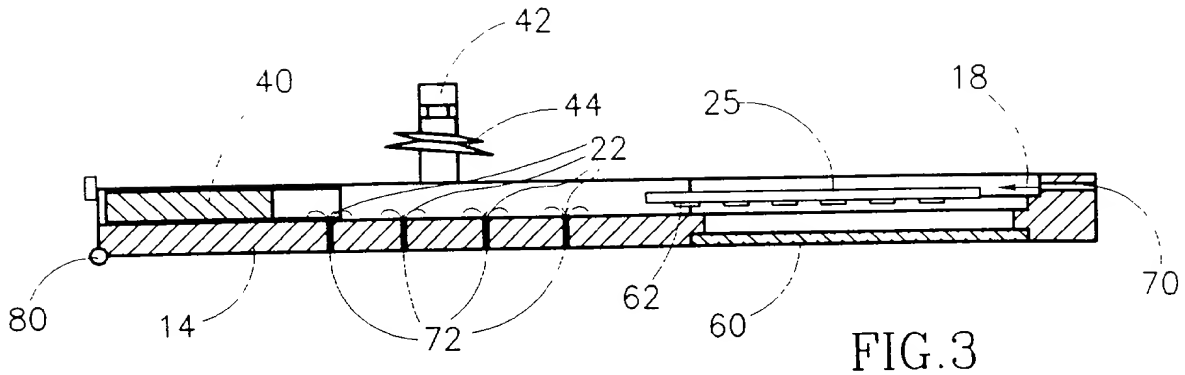


FIG.3

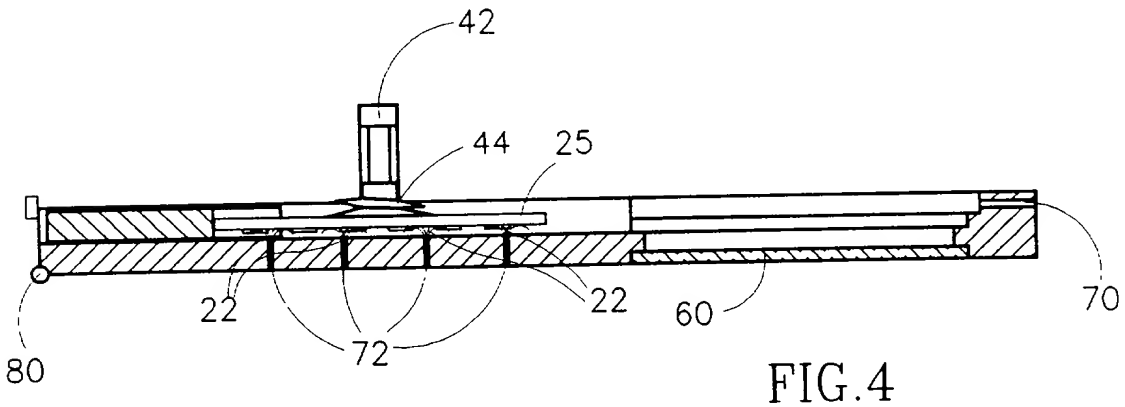


FIG.4

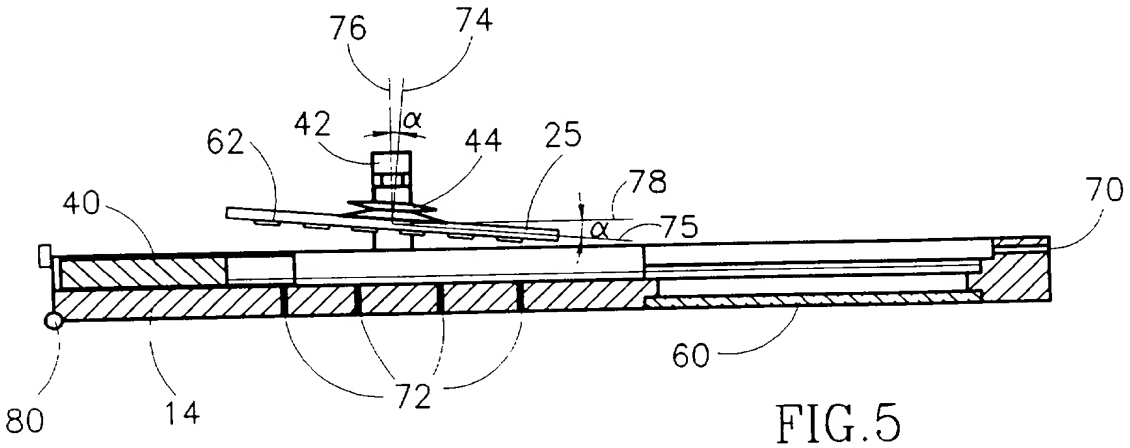


FIG.5

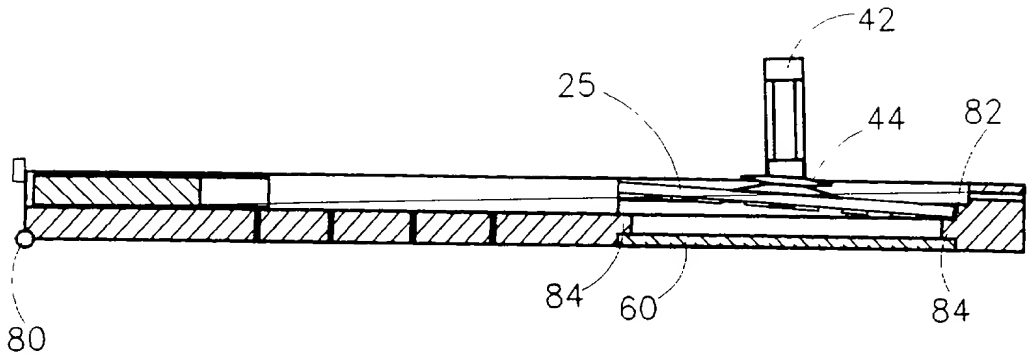


FIG.6

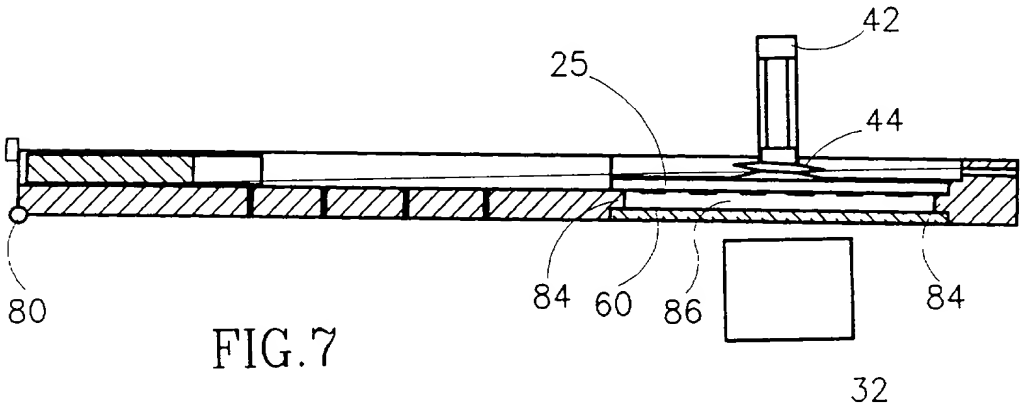


FIG.7

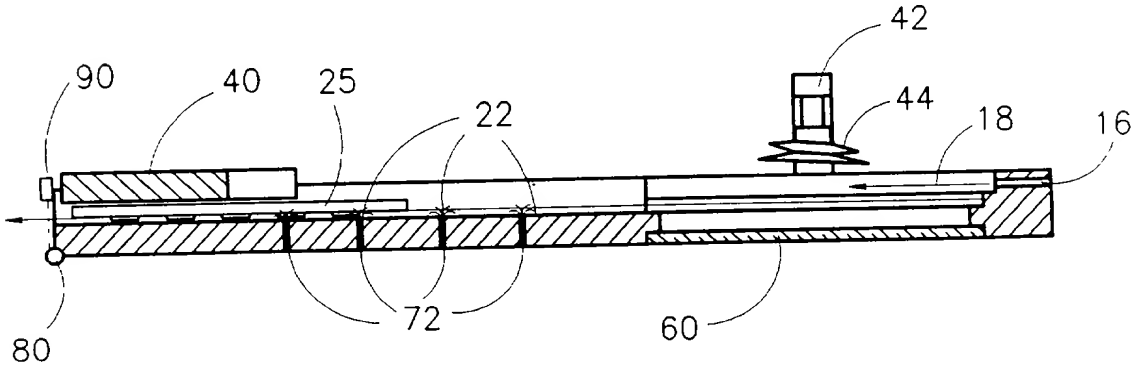


FIG.8

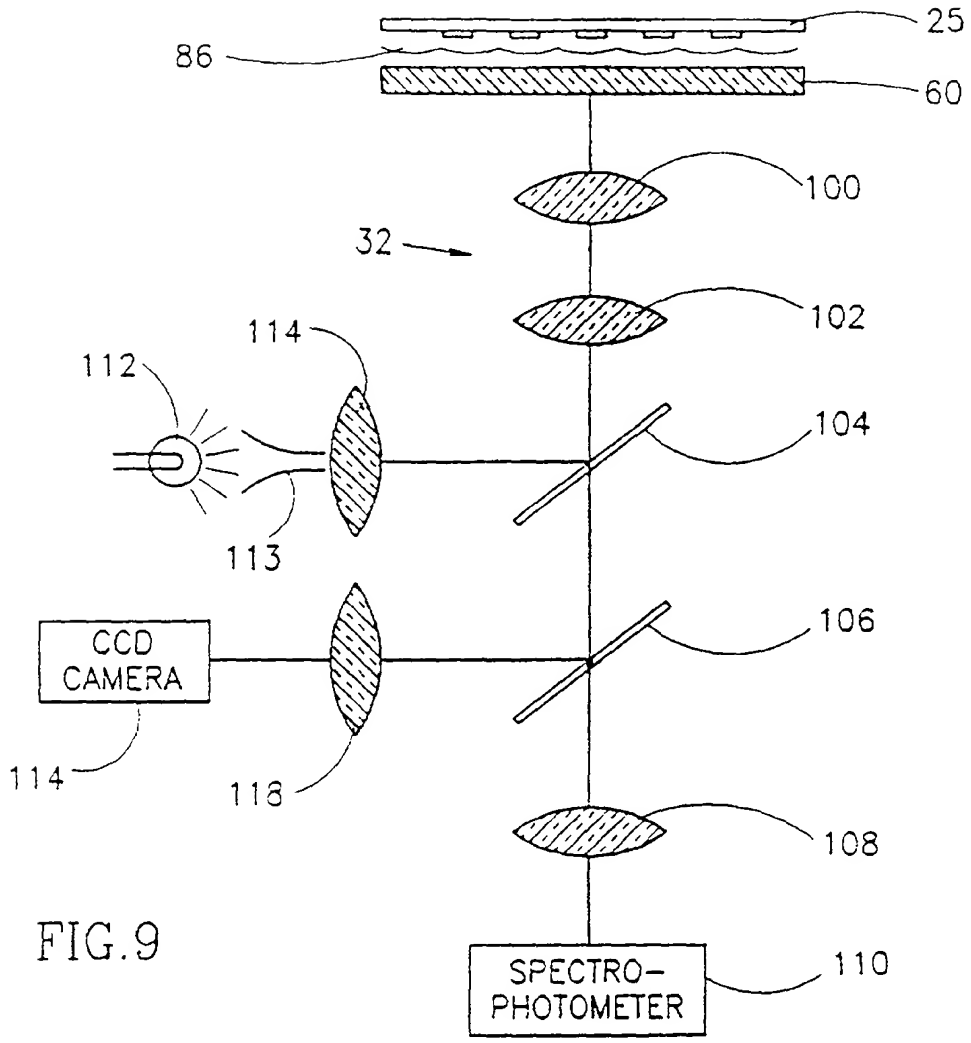

25
86
60
100
32
102
114
112
104
113
CCD
CAMERA
106
114
118
108
SPECTRO-
PHOTOMETER
110

FIG.9

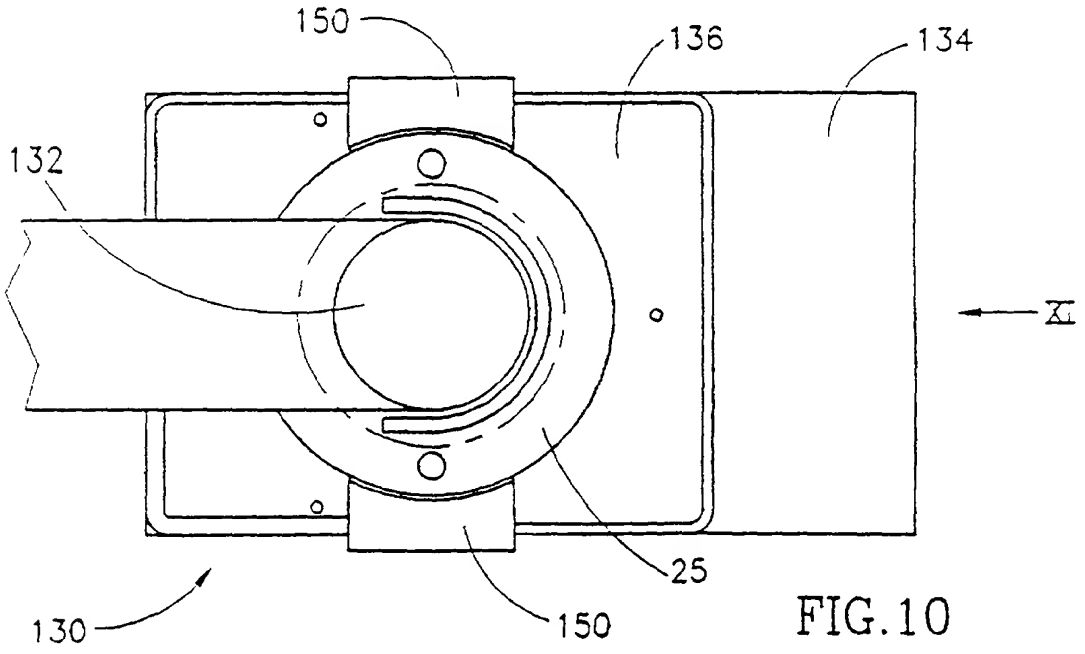

150
136
134
132
XI
25
130
150

FIG.10

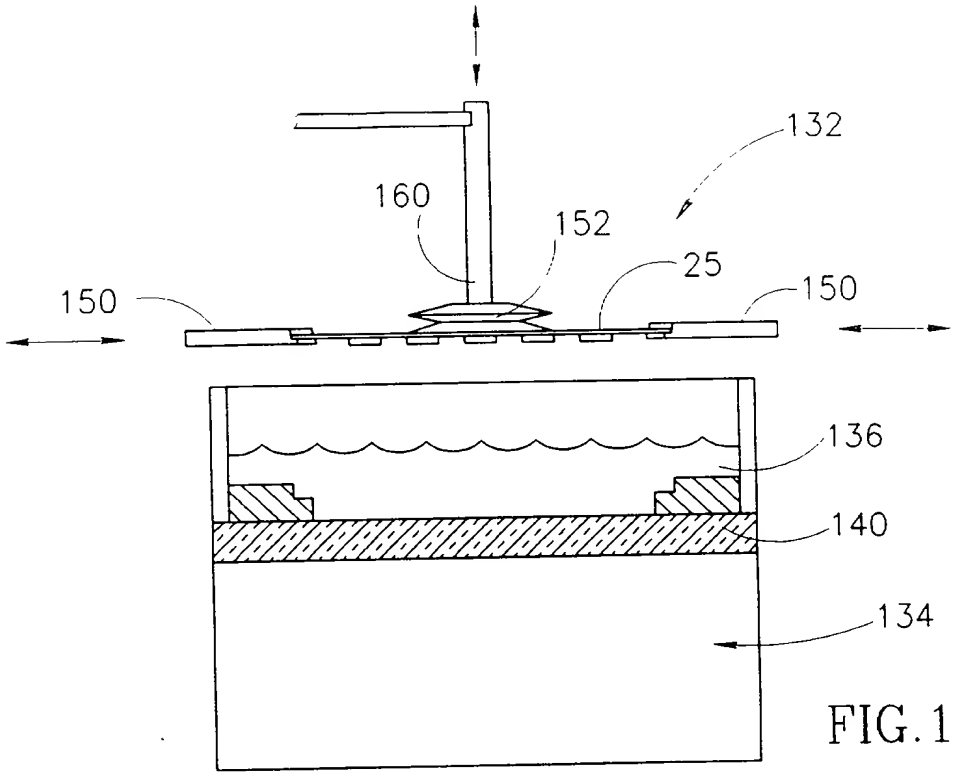

132
160
152
25
150
150
136
140
134

FIG.11

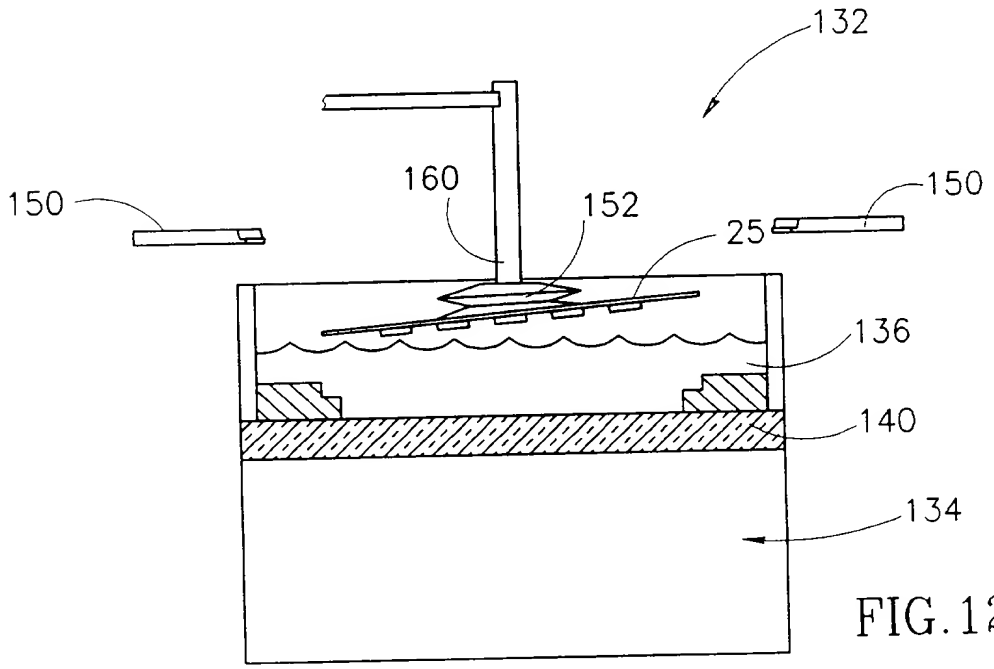

132
160
150
152
150
25
136
140
134

FIG.12

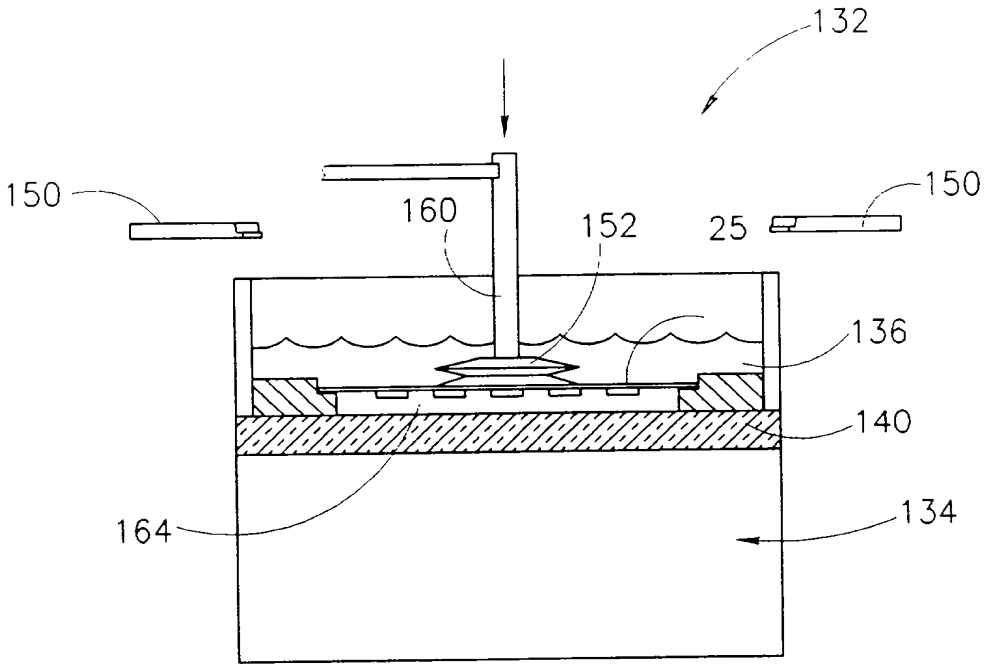


FIG.13

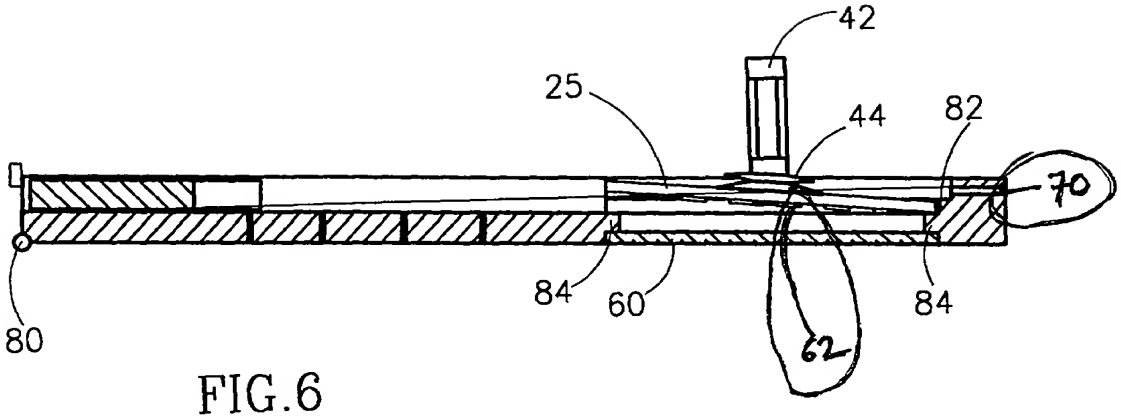


FIG.6

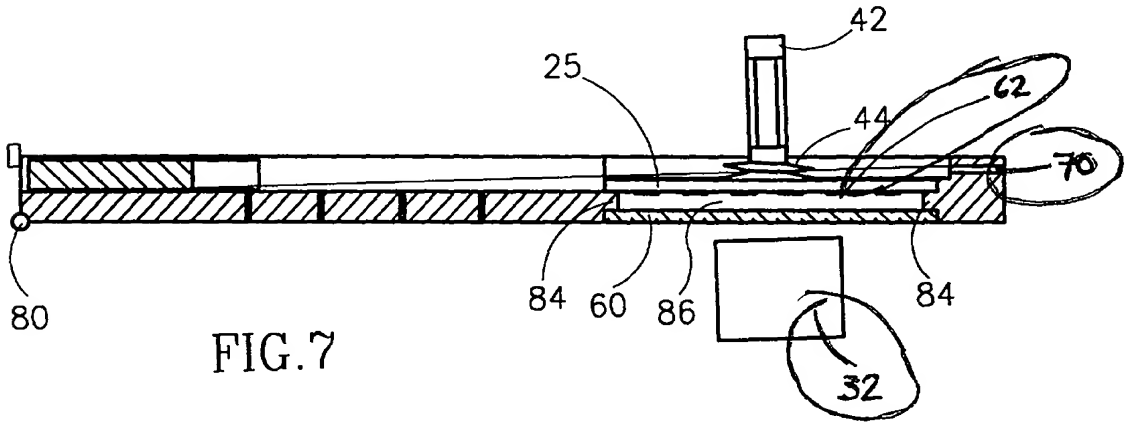


FIG.7

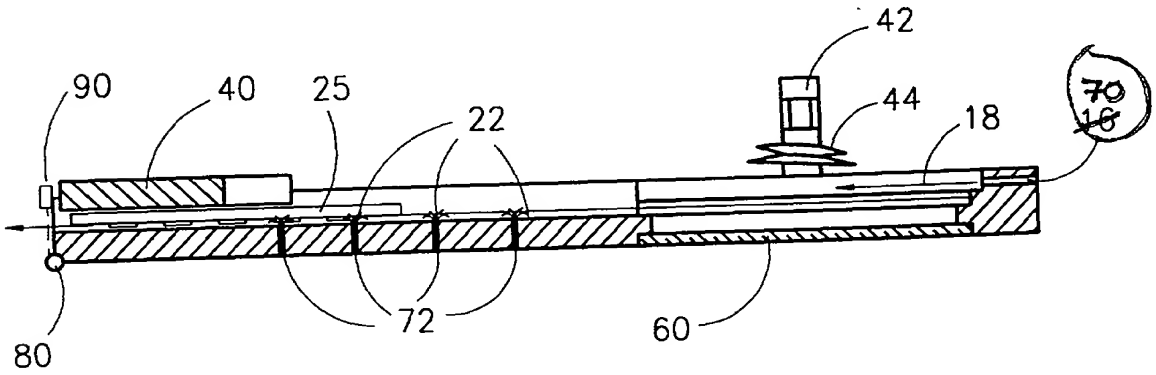


FIG.8

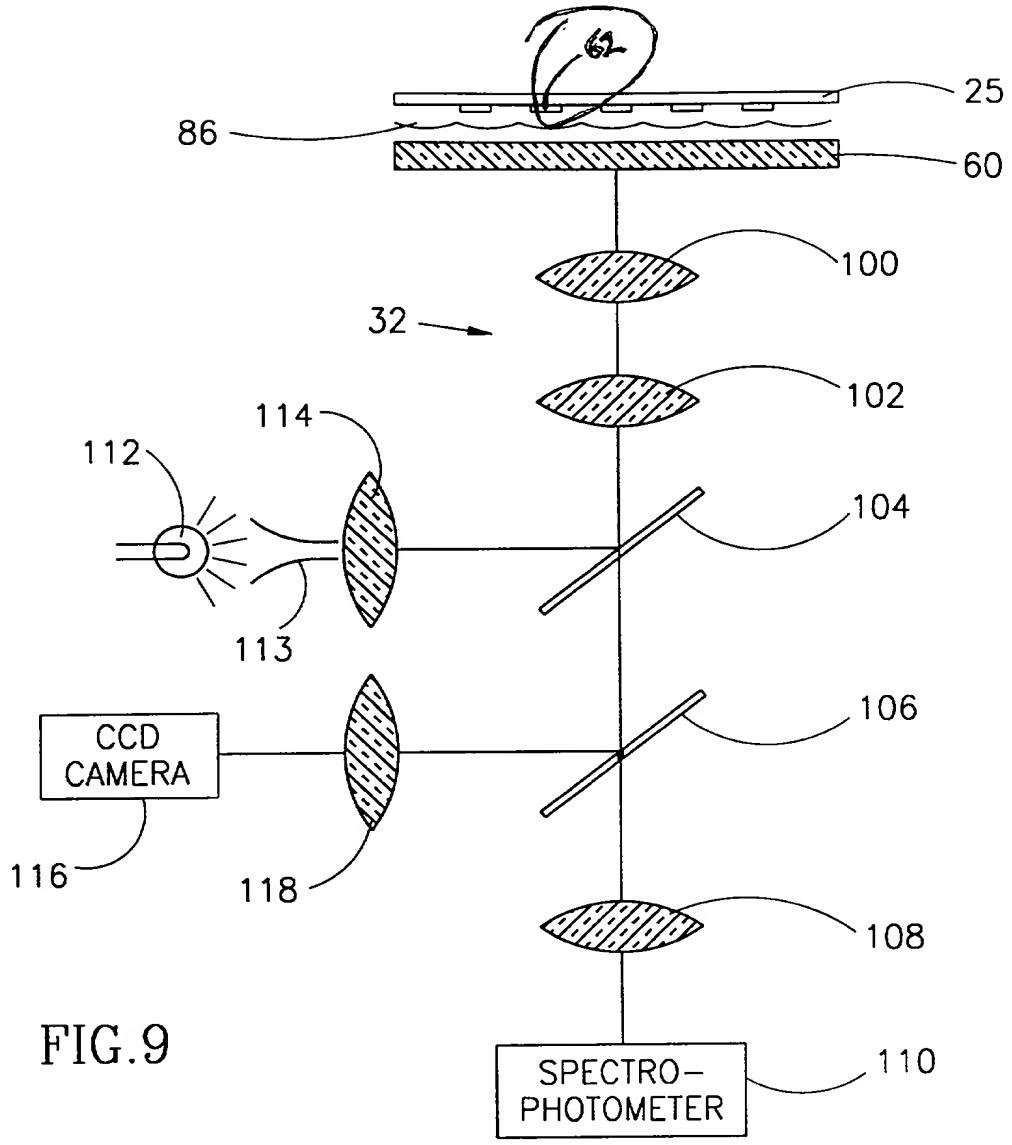

62
25
86
60
100
32
102
114
112
104
113
CCD
CAMERA
106
116
118
108
SPECTRO-
PHOTOMETER
110

FIG.9

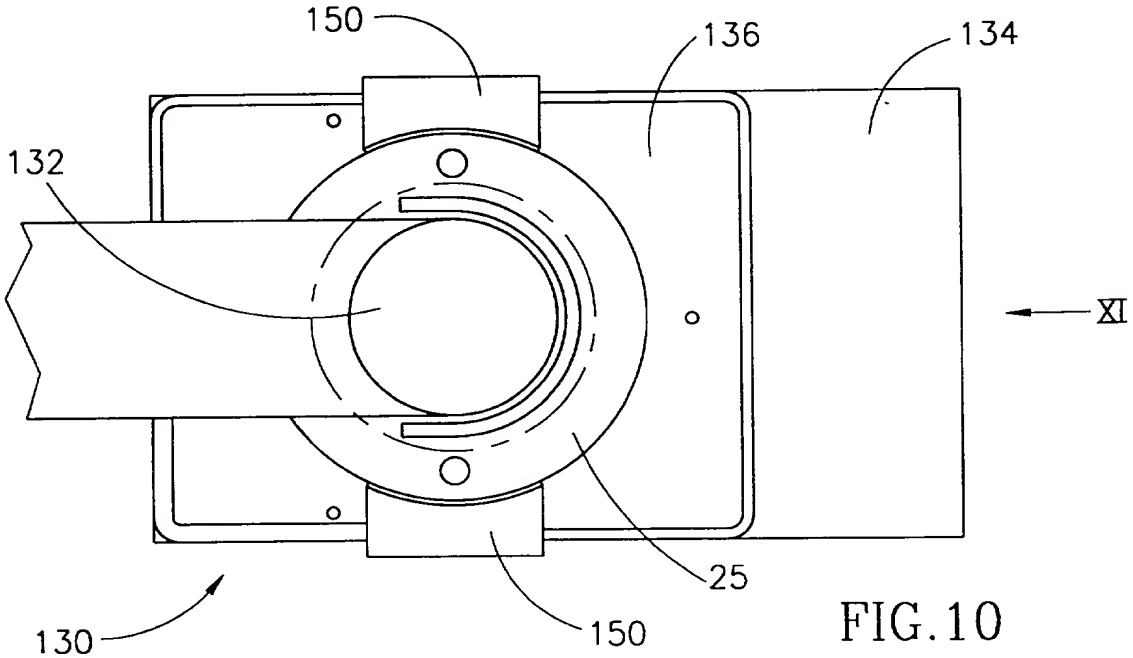

150
136
134
132
XI
25
130
150

FIG.10